



4M4

DS-11-04M04

4 fps 2k x 2k

CCD Camera



User's Manual and Reference

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DALSA Sales Offices

Waterloo	Europe	Asia Pacific
605 McMurray Rd Waterloo, ON N2V 2E9 Canada Tel: 519 886 6000 Fax: 519 886 8023 www.dalsa.com sales@dalsa.com	Breslauer Str. 34 D-82194 Gröbenzell (Munich) Germany Tel: +49 - 8142 – 46770 Fax: +49 - 8142 – 467746 www.dalsa.com europe@dalsa.com	Space G1 Building, 4F 2-40-2 Ikebukuro Toshima-ku, Tokyo 171-0014 Japan +81 3 5960 6353 (phone) +81 3 5960 6354 (fax) www.dalsa.com asia@dalsa.com

DALSA Worldwide Operations

Waterloo	Colorado Springs	Tucson	Europe	Asia Pacific
605 McMurray Rd Waterloo, ON N2V 2E9 Canada Tel: 519 886 6000 Fax: 519 886 8023 www.dalsa.com sales@dalsa.com	5055 Corporate Plaza Drive Colorado Springs, CO 80919 USA Tel: 719 599 7700 Fax: 719 599 7775 www.dalsa.com sales@dalsa.com	3450 S. Broadmont Dr. Suite #128 Tucson, AZ 85713- 5245 USA Tel: 520 791 7700 Fax: 520 791 7766 http://lifesciences.dals a.com sales@dalsa.com	Breslauer Str. 34 D-82194 Gröbenzell (Munich) Germany Tel: +49 - 8142 – 46770 Fax: +49 - 8142 – 467746 www.dalsa.com europe@dalsa.com	Space G1 Building, 4F 2-40-2 Ikebukuro Toshima-ku, Tokyo 171-0014 Japan +81 3 5960 6353 (phone) +81 3 5960 6354 (fax) www.dalsa.com asia@dalsa.com

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1

Introduction to the 4M4 Camera

1.1 Camera Highlights

Features

- 2048 x 2048 resolution, Full-frame CCD architecture.
- 4 fps single output at full resolution, 20 MHz data rate
- True 12-bit digitization
- High sensitivity with low dark current
- Progressive scan readout
- Pixel Flushing
- Selectable binning up to 4 x 4
- Programmable operation via RS232, including gain (1x and 4x), offset (-2047 to +2048), integration, binning, and triggering.
- 100% fill factor



Description

The 4M4 digital camera provides high-sensitivity 12-bit images with 2k x 2k spatial resolution at up to 4 frames per second (fps). The 4M4 is a full frame CCD camera using a progressive scan CCD to simultaneously achieve outstanding resolution and gray scale characteristics. A square pixel format and high fill factor provide superior, quantifiable image quality even at low light levels.

Applications

The 4M4 is an outstanding performer in fast, high resolution applications. True 12 bit performance provides up to 4096 distinct gray levels—perfect for applications with large interscene light variations. The low-noise, digitized video signal also makes the camera an excellent choice where low contrast images must be captured in challenging applications.

1.2 Image Sensor

Figure 1. Image Sensor Block Diagram

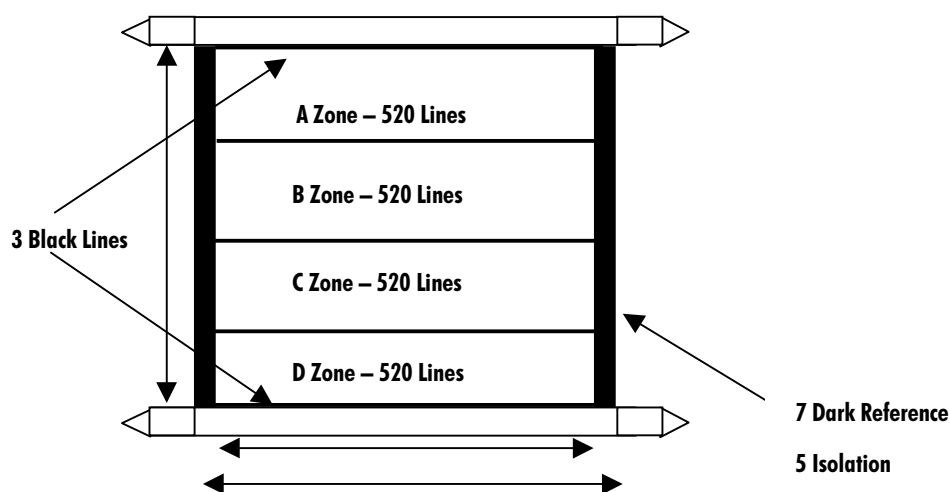


Table 1: Sensor Characteristics

Characteristic	
Image Zone	28.670 mm (H) x 28.67 mm (V)
Pixel size	14μm x 14μm
Active pixels	2048 (H) x 2080 (V)
Total number of pixels	2072 (H) x 2080 (V)
Dark Reference Columns	Left: 7 Right: 7
Isolation Columns	Left: 5 Right: 5
Optical black lines	Top (A): 3 Bottom (D): 3
Extra Output Stages	Left: 18 Right: 18

Table 2. Grade E Sensor Cosmetic Specifications

	Z1		Z1 + Z2	
Type (Black or White)	White defects in darkness at 25 °C	Defects at VSAT/2	White defects in darkness at 25 °C	Defects at VSAT/2
Pixels affected by blemishes. Area	600		2000	
Maximum (pixels)	5 x 5		5 x 5	
Amplitude a	$\alpha > 40 \text{ mV}$	$20\% < \alpha $	$\alpha > 40 \text{ mV}$	$20\% < \alpha $

Column Number	3	10	10	40
Maximum Amplitude α	$\alpha > 2 \text{ mV}$	$10\% < \alpha $	$\alpha > 2 \text{ mV}$	$10\% < \alpha $

Blemish Definition:

1. Column: One pixel wide and ≥ 7 pixel high defect whose height is constant with light level.
2. White Blemishes are temperature dependent. They are specified in darkness at 25 °C.
3. Black Blemishes are independent of temperature, but amplitude is proportional to the mean output voltage. They are specified as a percentage of mean illumination up to VSAT/2 min.
4. Traps are defects (White + Black) in darkness at +25 °C.
5. Is the amplitude of video signal of blemishes.
6. Eg: $20\% < \alpha$
7. For Amplitude $< 20\%$, pixel is not a blemish.
8. Z1 is a square area whose side is half the height of the image zone, centered in the image zone.
9. Z2 is the rest of the image zone.
10. Image grade is measured on VOS output signal, with four outputs operating mode (1s integration time in darkness, 100kHz vertical frequency and 5 MHz horizontal frequency.)
11. Illumination conditions: 3200K Halogen lamp + BG38 filter + F/3.5.

1.3 Camera Performance Specifications

Table 3: 4M4 Camera Performance Specifications

Physical Characteristics	Units				
Resolution	H x V pixels	2048x2048			
Pixel Size	μm	14 x 14			
Pixel Fill Factor	%	100			
Size	mm	95x95x141			
Mass	kg	0.85			
Power Dissipation	W	< 21			
Lens Mount		F mount			
Aperture	mm	28.67 x 28.67			
Regulatory Compliance		Pending			
Shock Immunity		Pending			
Vibration Immunity		Pending			
Operating Ranges	Units	Min.	Max.		
Frame Rate	fps		4		
Data Rate	MHz		20		
Data Format	RS-422		12 bit		
Responsivity	DN/(nJ/cm ²)		18@540 nm		

Operating Temp	°C	10	45		
+15 Input Voltage	V	+14.925	+15.075		
- 15 Input Voltage	V	- 15.075	- 14.925		
+5 Input Voltage	V	+4.975	+5.025		
-5 Input Voltage	V	- 4.975	- 5.025		
Nominal Gain Range		1x	4x		
Calibration Conditions	Units	Setting	Min.	Max.	
Data Rate	MHz	20			
Frame Rate	Hz	4			
Video Output Level	DN	4095			
+15 Input Voltage	V	+15	+14.925	+15.075	
- 15 Input Voltage	V	- 15	-15.075	-14.925	
+5 Input Voltage	V	+5	+4.975	+5.025	
-5 Input Voltage	V	- 5	- 4.975	- 5.025	
Ambient Temperature	°C	25			
Binning		1x1	1x1	4x4	
Gain	X	1x	1x	4x	
Electro-Optical Specifications	Units	Min.	Typical	Max.	
Dynamic Range	dB		65		
Pixel Response Non-Uniformity	%rms		2.5		
System Noise	DN(rms)			1.2	

2

Camera Hardware Interface

2.1 Installation Overview

This installation overview assumes you have not installed any system components yet.

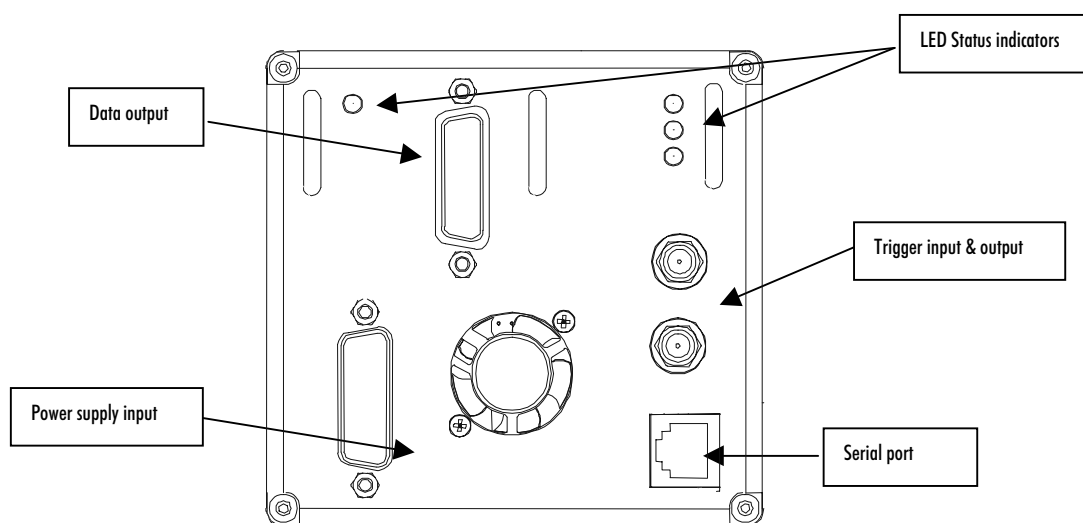
In order to set up your camera, you should take these initial steps:

1. Power down all equipment.
2. Following the manufacturer's instructions, install the frame grabber (if applicable). Be sure to observe all static precautions.
3. Install any necessary imaging software.
4. Before connecting power to the camera, test all power supplies. Ensure that all the correct voltages are present at the camera end of the power cable (See section 1.3 Camera Performance Specifications on page 7 for appropriate voltages). Power supplies must meet the requirements defined in section 2.4 Power Input on page 11.
5. Inspect all cables and connectors prior to installation. Do not use damaged cables or connectors or the camera may be damaged.
6. Connect data, serial interface, and power cables.
7. After connecting cables, apply power to the camera. The POST (power on self test) LED on the back of the camera should glow green after one second to indicate that the camera is operating and ready to receive commands.

2.2 Input/Output

The camera provides 12-bit RS-422 data and synchronization signals through the data output connector. Camera functions such as integration time, binning, camera gain, and offset are all controllable by the user via the RS232 serial port. The camera is capable of free running operation or may be triggered externally via the input TRIGGER IN. TRIGGER OUT allows the synchronization of shutters or illumination sources in free running or externally triggered modes.

Figure 2: Camera Inputs/Outputs



2.3 LED Status Indicators

There are four LED's visible on the rear cover of the camera that indicate the status of the camera.

Table 4: LED Functions

LED Label	Color	LED "ON"	LED "OFF"
ON	Green	Camera is receiving power	There is no camera power
POST	Green	Camera Power On Self Test successful	Camera failed Power On Self Test
BIN	Red	Camera is operating in a binning mode	Camera is operating unbinned (1x1)
MODE	Red	Camera is in an external trigger mode (uses external signal to trigger image capture)	Camera is triggering image capture internally

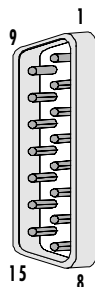
2.4 Power Input



WARNING: It is extremely important that you apply the appropriate voltages to your camera. Incorrect voltages will damage the camera.

Table 5: Power Connector Pinout

Pin	Symbol
1	+5V
2	+5V
3	- 5V
4	+15V
5	- 15V
6	- 15V
7	GND
8	GND
9	+5V
10	- 5V
11	+15V
12	+15V
13	- 15V
14	GND
15	GND



DB15M

(AMP Part # 747236-4 or equivalent)

The camera has the following input power requirements:

V (DC)	±%	Max Ripple mV	A
+15	5.0	< 50	0.10
-15	5.0	< 50	0.25
+5	5.0	< 50	1.60
-5	5.0	< 50	0.13

Note: Performance specifications are not guaranteed if your power supply does not meet these requirements.

DALSA offers a linear power supply (with cables) that meets the 4M4's requirements (Universal Power Supply, part number 24-00001-02, contact DALSA for more information), but it should not be considered the only choice. Many high quality supplies are available from other vendors. DALSA assumes no responsibility for the use of these supplies.

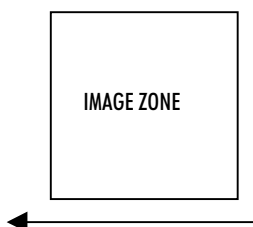
When setting up the camera's power supplies, follow these guidelines:

- Do not connect or disconnect cable while power is on.
- Do not use the shield on a multi-conductor cable for ground.
- Keep leads as short as possible to reduce voltage drop.
- Use high-quality linear supplies to minimize noise.

2.5 Data Output

Figure 3 represents the data channel output (image viewed from the front of the CCD).

Figure 3: Data Channel Output



Connector and Pinout

Figure 4: Molex Part # 70928-2000 or equivalent

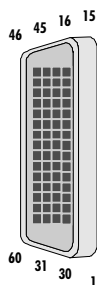


Table 6: DATA Connector Pinout

Pin	Symbol	Pin	Symbol	Pin	Symbol	Pin	Symbol
1	DA0+	16	Reserved	31	NC	46	GND
2	DA0-	17	DA7+	32	NC	47	NC
3	DA1+	18	DA7-	33	NC	48	NC
4	DA1-	19	DA8+	34	NC	49	NC
5	DA2+	20	DA8-	35	NC	50	NC
6	DA2-	21	DA9+	36	NC	51	NC
7	DA3+	22	DA9-	37	NC	52	NC
8	DA3-	23	DA10+	38	NC	53	Reserved
9	DA4+	24	DA10-	39	NC	54	Reserved
10	DA4-	25	DA11+	40	NC	55	VSYNC-
11	DA5+	26	DA11-	41	NC	56	VSYNC+
12	DA5-	27	NC	42	NC	57	HSYNC-
13	DA6+	28	NC	43	NC	58	HSYNC+
14	DA6-	29	NC	44	NC	59	PIXCLK-
15	Reserved	30	NC	45	GND	60	PIXCLK+

NC = No Connect. These pins are unused.

WARNING. To insure proper connection and to prevent damage to the connector, care must be taken when connecting data cables to the camera



Data Signals

Table 7: Data Signal Definitions

Signal	Description
D*0+, D*0-	Data bit 0 true and complement--Output. (Least significant bit)
D*1+, D*1-	Data bit 1 true and complement--Output.
D*2+, D*2-	Data bit 2 true and complement--Output.
D*3-D*10+,- etc.	Etc.
D*11+, D*11-	Data bit 11 true and complement--Output. (Most significant bit)

**IMPORTANT:**

This camera uses the *falling* edge of the pixel clock to register data.

Digitized video data is output from the camera as RS-422 differential signals using a Molex 60-pin connector on the rear panel (labeled “DATA”). The data is synchronous and is accompanied by a pixel clock and clocking signals.

Note: Data frequency is dependent on binning mode. See section 3.9 Triggering, Integration, and Frame Rate Overview.

Data Clocking Signals

Table 8: Clock Signal Descriptions

Signal	Description
PIXCLK+, PIXCLK-	Pixel clock true and complement. 20MHz (unbinned) -- Output. Data is valid on the falling edge. Note that data and PIXCLK frequency is dependent on binning mode. See section 3.9 – Triggering, Integration, and Frame Rate Overview.
HSYNC+, HSYNC-	Horizontal sync, true and complement--Output. HSYNC high indicates the camera is outputting a valid line of data. The number of valid lines in a frame depends on binning mode. See section 3.9 – Triggering, Integration, and Frame Rate Overview.
VSYSN+, VSYSN-	Vertical sync, true and complement--Output. VSYNC high indicates the camera is outputting a valid frame of data.

2.6 Serial Communication

Connector and Pinout

The serial interface provides control of integration time (shuttering), video gain and offset, pixel binning, external trigger and external integration (for information on how to control these functions, see “Operating the Camera” later in this document). The remote interface consists of a two-wire (plus ground) full duplex RS-232 compatible serial link, used for camera configuration, and two back panel SMA coax connectors used for external trigger input and output

The camera uses an RJ-11 telephone-style connector for communications, with four conductors installed in a six-position connector. Note that both four- and six-conductor plugs may be used interchangeably with the RJ-11 jack.

IMPORTANT: Both the PC/AT and the camera are configured as “DTE” (Data Terminal Equipment) devices requiring the TXD and RXD lines to be swapped when interconnecting the two (note that pin 4, normally the yellow wire, is not used on the RJ-11.) That is, the TXD pin represents DATA OUT and the RXD pin represents DATA IN on both devices, so that one device’s TXD line must connect to the other device’s RXD line and vice-versa.

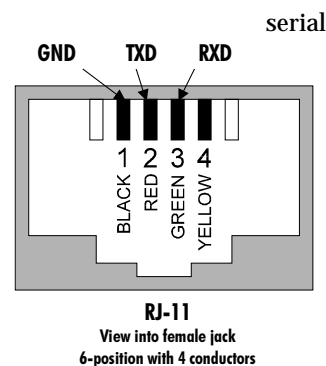


Figure 5: 25 Pin Serial Port Connector to Camera RJ-11 Connector

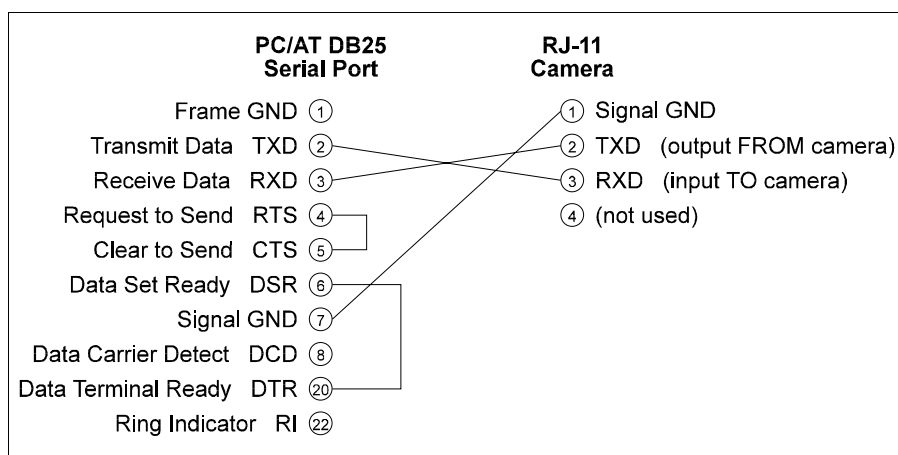
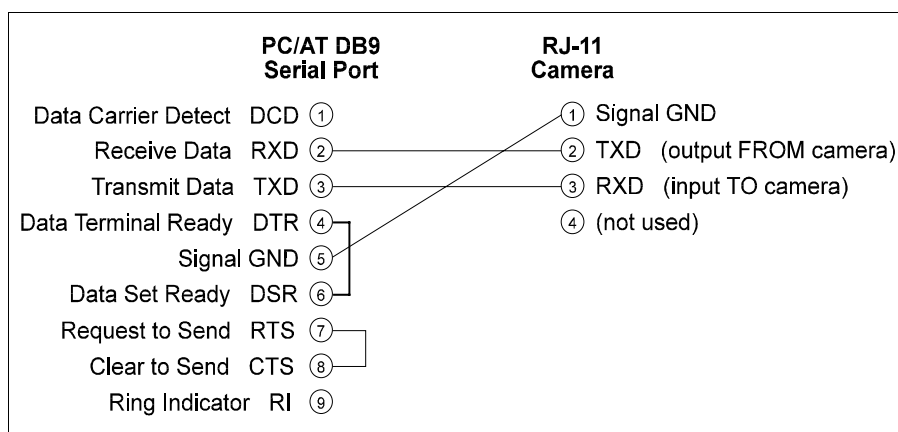


Figure 6: 9 Pin Serial Port Connector to Camera RJ-11 Connector



Serial Communication Settings

Table 9: Serial Port Configuration

Serial Port Configuration	
Baud	9600, fixed
Start bits	1
Data bits	8
Stop bits	1
Parity	None

The serial interface operates at RS-232 levels with fixed parameters of 9600 baud, 1 start bit, 8 data bits, 1 stop bit, and no parity. The interface uses only three wires, for received data, transmitted data, and ground. In general, when writing data you must start with a write command byte followed by a data byte. Reading a camera register requires only a single read command byte.

WARNING: Due to initialization sequencing after power-up, no commands should be sent to the camera for a minimum of 1 second after power up.



The remote interface connector, on the camera's rear panel, is specified as a low-profile RJ-11 modular connector. The connector is a 6-position model, but only the center four positions are populated with contacts. It will mate with either the 4-position or 6-position cable plugs. This type of connector typically requires special assembly tools; complete cable assemblies are available from suppliers such as Digi-Key:

Serial Cable Source

Digi-Key
 701 Brooks Ave. South
 Thief River Falls, MN 56701
 1-800-344-4539
 cable part number:
 H2643-14-ND (14 feet)

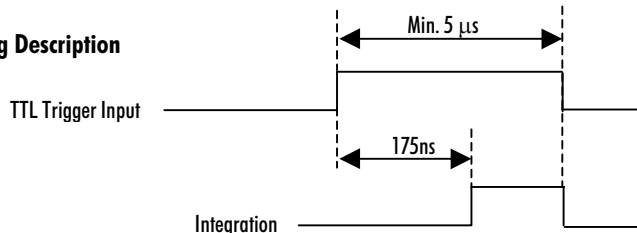
DALSA provides serial cables in 3 lengths: 10', 20' and 50'. Part number CL-31-00004-xx (where xx refers to the cable length in feet).

2.7 TTL Trigger Input and Output

Connector

The camera uses an SMA connector (labeled TRIGGER IN) to allow the user to provide a standard TTL signal to control camera integration and readout. The input is high impedance ($>10K$) allowing the user to terminate at the SMA input as needed. The camera has another SMA connector (TRIGGER OUT) that provides a standard TTL output which is high whenever the camera is integrating.

Figure 7: Trigger Timing Description



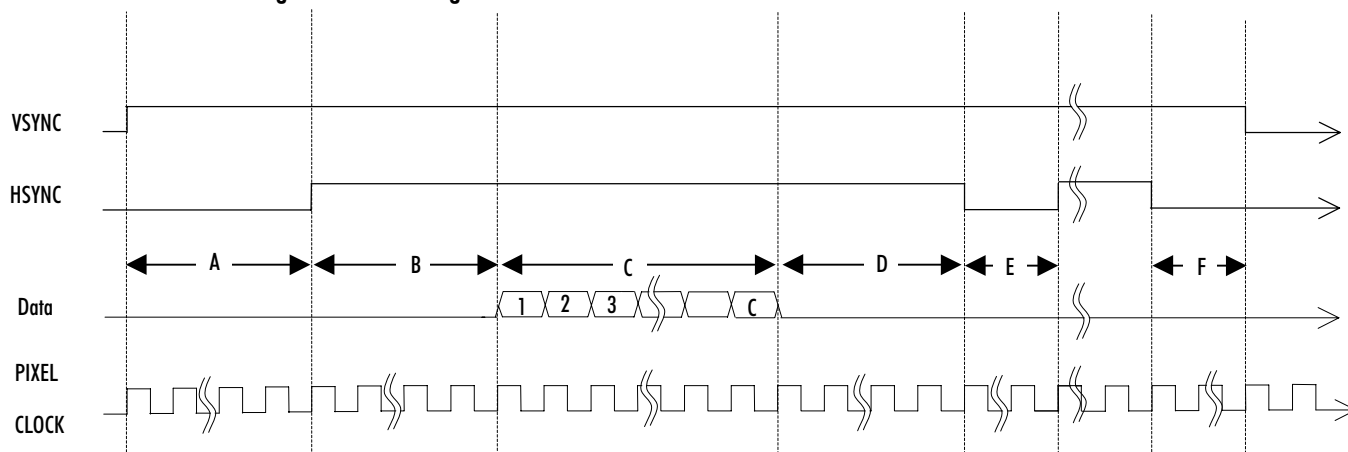
2.8 Integration Time

The minimum integration time (or shutter time) is $5 \mu s$. If the camera is not strobed or externally shuttered, an integration time of $5 \mu s$ will create smeared images. To reduce smearing, the integration time should be 1.5x to 2x the readout time when not using a strobe or external shutter.

2.9 Timing

The 4M4 pixel clock runs at 20 MHz, so each pixel clock cycle will be $1/20,000,000$ or 50 ns. The following diagram and tables describe the correct timing requirements for the 4M4 camera.

Figure 8: 4M4 Timing



“A” represents the number of falling clock edges from the rising edge of VSYNC to the rising edge of HSYNC.

“B” represents the number of falling clock edges prior to the first word. (Pre-Scan pixels)

“C” represents the number of words per line.

“D” represents the number of falling clock edges between the last word and the falling edge of HSYNC. (Post-Scan pixels)

“E” represents the number of falling clock edges between a falling HSYNC and a rising HSYNC.

“F” represents the number of falling clock edges from the falling edge of HSYNC to the falling edge of VSYNC



IMPORTANT:

This camera uses the *falling* edge of the pixel clock to register data.

Table 10: HSYNC Pixel Timing

Horizontal Binning Mode	A	B	C	D	E	F
1x	31	10	2048	0	182	150
2x	15	12	1024	0	164	296
4x	7	12	512	0	152	582

Table 11: VSYNC Pixel Timing (HSYNC falling edges/VSYNC falling edge)

Vertical Binning Mode	Pre-Scan Lines/Frame	Active Lines/Frame	Post Scan Lines/Frame
1x	16	2048	16
2x	8	1024	8
4x	4	512	4

3

Camera Operation

3.1 How to Control the Camera

The 4M4's RS-232-compatible serial interface allows you to control its configuration and operation, including:

- Triggering Mode
- Binning
- Integration Time
- Gain
- Offset
- Reset

Command Protocol Overview

The camera accepts 8-bit command/value pairs via its RJ-11 serial port using RS-232 compatible signals. Camera commands are “clock” commands which apply to the electronics that drive the image sensor. These include clock generation, integration time, and binning. Each set of commands includes read and write variants. With the exception of reset commands, all 8-bit write commands must be followed by an 8-bit data byte. The commands are interpreted as follows:

Serial Port Configuration

Baud	9600, fixed
Start bits	1
Data bits	8
Stop bits	1
Parity	None



WARNING: Any commands not listed should be considered invalid. Writing to invalid addresses may overwrite camera calibration information, requiring the camera to be returned for recalibration.

WARNING: Due to initialization sequencing after power-up, no commands should be sent to the camera for a minimum of 1 second after power up.

3.2 Control Register Reference

A number of functions and modes depend on the control register settings. These settings are detailed in the following sections.

The “Write Control Register” command is used to write a register that controls specific camera triggering and test functions. This command must be followed by a data byte with bits defined as shown in the following table.

The “Read Control Register” command allows interrogation of the camera to determine current configuration of the control register.

Table 12: Control Register Bit Definitions

Register	Write Command	Read Command	Bit	Function	Default
Reset	80h		7:0	Resets all registers to default values	NA
Camera Type	NA	C3h	7:0	Read camera type	14h
Firmware Rev	NA	C5h	7:0	Read firmware revision	NA
Register 1	81h	C1h	7	Always 0	0
			6:5	Not Used	0
			4	Video Gain 0 = 1x 1 = 4x	0
			3:2	Binning Mode 00=1x1 01=2x2 10=4x4	00
			1	Trigger Mode 0 = External 1 = Internal	0
			0	Integration Mode 0 = External 1 = Internal (Programmed)	0
Register 2	82h	C2h	7	Always 0	0
			6:0	Integration Time 7Dh = 500 us 7Bh = 1 ms 77h = 2 ms 6Fh = 4 ms 5Fh = 8 ms 3Fh = 16 ms	0h
Register 3	84h	C4h	7:0	Pixel Offset MS	00h
Register 4	88h	C8h	7:4	Reserved (Always 0)	0h
			3:0	Pixel Offset LS	0h

3.3 Reading the Camera Type

This read command returns an 8-bit value unique to the type of camera interrogated. A 4M4 will return a value of 14h when this command is issued. This is useful for applications that need to function with multiple DALSTAR camera types.

Example: Read the camera type

	Command	Value Returned (4M4)
Binary	1100 0011	0001 0100
Hex	C3h	14h

3.4 Reading the Firmware Revision

This command returns a byte in which the lower nibble is the revision number for the clock board firmware and the upper nibble is undefined. The ability to read this value may assist in customer support issues.

Example: Read the firmware version

	Command
Binary	1100 0101
Hex	C5h

3.5 Resetting the Camera

This is the only other “write” command that is not followed by a data byte. This command resets all clock board registers to their default values (the values used at power-up).

Table 13: Default values in effect after reset

Feature	4M4 Default
Frame Rate (fps)	4
Integration Time (ms)	External
Resolution (pixels)	2048x2048
Video Gain	1x
Binning Mode	1x1
Pixel Offset	0
Triggering	External
Integration Control	External
Data Rate (MHz)	20

Example: Reset the Camera

Use this command to reset the camera:

	Command	Value
Binary	1000 0000	-
Hex	80h	-

3.6 Adjusting Gain

Bit [4] of register 1 is the Video Gain control bit. When this bit=0 the video channel gain=1x. When this bit =1, the video channel gain=4x.

Example: Setting the Gain

Use this command to set the gain to 4x:

	Command	Value
Binary	1000 0001	0001 0000
Hex	81h	10h

Note: The register containing the Gain bit also controls other configuration data. All bits must be set appropriately.

3.7 Adjusting User Offset

User offset is adjustable from -2047 to +2048 by a 12 bit value as an MS and LS byte. The offset data is only written when the most-significant 8 bits are written to register 3. Therefore, the lower 4 bits should be written first to register 4, followed by the upper 8 bits, which will cause the offset to be applied to the pixel output.

The pixel offset data is written as a 2's complement number. Therefore, either positive or negative offsets can be added to the pixel output to enhance the image contrast.

The offset value that is programmed effects the pixel offset by a ratio of about 8 to 5. So, for that example, if an offset value of a positive 16 is entered to registers 2 and 3 the resulting pixel data will be adjusted by a positive 10.

Table 14: Pixel Offset Examples

Programmed Offset Decimal/2's Complement	Register 4	Register 3	Resulting Pixel Offset
88 (058h)	X8h	05h	55 (37h)
-96 (FA0h – 2's)	X0h	FAh	-60 (-FC4h)
152 (098h)	X8h	09h	95 (5Fh)
-2040 (808h)	X8h	80h	-1275 (-4FBh)

The read user offset commands allow you to read back this information from the camera.

Reading Offset from the Camera

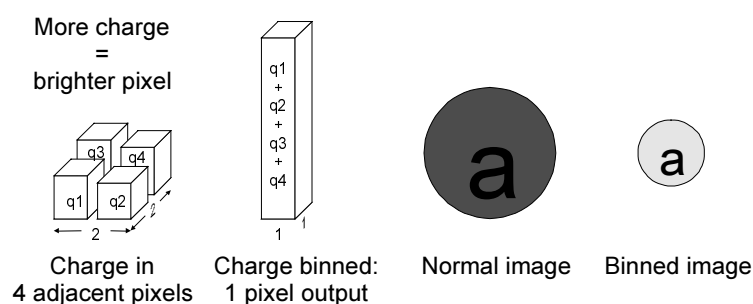
To read the offset setting from the camera, use these commands:

	Read LSB	Read MSB
Binary	1100 1000	1100 0100
Hex	C8h	C4h

3.8 Controlling Binning

Binning increases the camera's light sensitivity by decreasing horizontal and vertical resolution—the charge collected by adjacent pixels is added together.

Figure 9: Example of 2x2 Binning



The 4M4 is capable of up to 4x4 binning. To enable binning, you must write bits [3:2] to control register 1.

Binning mode affects the pixel clock rate, maximum frame rate, resolution, and readout time. Reference section 3.9 – Triggering, Integration, and Frame Rate Overview.

Example: Setting the camera to 2x2 binning mode

	Write Binning Register with 2x2 mode	
	Command	Value
Binary	1000 0001	**** 01**
Hex	81h	**h

Note: The register containing the Binning bits also controls other configuration data. All bits must be set appropriately.

Whenever the camera is in binning mode, the **BIN** LED on the right side of the rear cover will light to indicate the 2x2 or 4x4 mode.

3.9 Triggering, Integration, and Frame Rate Overview

Image capture triggering, integration, and frame rate are closely related.

- Integration time can be less than 1/frame rate, but it can never be greater than 1/frame rate.
- You can program fixed integration and frame rates (or use defaults) and let the camera “free run.”
- You can program fixed integration time and supply a (asynchronous) trigger signal to control frame rate by supplying a TTL pulse on the SMA connector. This is referred to as “Programmed Integration/External Trigger Mode.”
- You can also have the camera integrate as long as an asynchronous TTL pulse is held high. This pulse will therefore control both integration time and frame rate. This is also known as “External Integrate Mode.”

For a given frame rate, the maximum integration time is limited to the frame period less an overhead factor required for proper operation of the CCD. Maximum integration time is defined by this equation:

$$\text{Max Integration Time} = (1/\text{Frame Rate}) - \text{Readout Time}$$

This equation is valid for all binning modes, free running, external trigger and external integrate modes.

Note: Binning mode impacts the Read Time and limits Integration Time.



WARNING: Do not set integration time higher than the limits of the equation above. Unpredictable operation may result

Table 15: Integration/Frame Rate Limits

Binning	Read out Time (mS)	Max Frame Rate	Data Rate (MHz)	Resolution
1 x 1	233	4	20	2048 x 2048
2 x 2	125	8	10	1024 x 1024
4 x 4	70	14	5	512 x 512

The default Integration time was chosen to give a frame rate of 4 fps (see section 3.11 Controlling Frame Rate).

3.10 Controlling Integration (Shutter Time)

The 4M4 allows you to control integration (also known as exposure time or shutter time) in three ways.

- **Programmed Integration/Free Running:** (default) The camera free runs with the internally programmed integration time and frame rate
- **Programmed Integration/External Trigger:** The camera will integrate for the internally programmed time when triggered by a TTL high pulse on the SMA connector.

- **External Integration:** The camera will integrate as long as the TTL pulse on the TRIGGER IN SMA connector is high. The integration time is effectively the input pulse width. In this mode, TRIGGER IN also controls the frame rate.

The register settings required for each mode are defined in the following table:

Table 16: Integration/Trigger Modes

Mode	Register 1 Bit [0] INTEGRATE	Register 1 Bit [3] EXT Trigger
Programmed Integration/Free Running	0	0
Programmed Integration/External Trigger	0	1
External Integration	1	1

Whenever the Integrate Mode or External Trigger Mode bits are set the **MODE** LED on the right side of the rear cover will light to indicate that an externally trigger mode is active.

Free Running (Programmed Integration):

This mode is the camera's default. Write the 7 bit integration value to bits [6:0] in register 2. The camera will run at maximum speed for the programmed integration time.

The camera's default integration time value is 32 ms.

Example: Set integration time to 2 ms

1. Using the command 81h, set bit [0] of the data byte to 1 (Integrate Mode = Internal) and bit [1] of the data byte to 1 (Trigger Mode = Internal).

NOTE: All bits within the register are written at one time. Ensure the correct value for all bits are used when changing camera modes.

2. Use commands 82h to set the 7-bit integration time value.

Value = 2 ms

= 77h

Write Integration Byte		
	Command	Value
Binary	1000 0010	0111 0111
Hex	82h	77h

Programmed Integration/External Trigger

For external SMA controlled triggering with a programmed integration time, a TTL rising edge on the **TRIGGER IN** signal triggers the camera to acquire one frame of data. Integration begins within 112 ns after the rising edge (132 ns in binning mode) and stops when the programmed integration time has completed. After that single frame acquisition, the camera outputs the just acquired frame and “re-arms”, thus waiting for a new External Trigger signal to trigger a new frame acquisition. The camera is “armed” when the read out of the acquired frame is completed. *No additional rising edges, or triggers, should be allowed during the image acquisition or frame read out.*

When the camera is in External Trigger Mode, the MODE LED will be illuminated on the camera back to indicate the camera is expecting a signal on the SMA connector.

External Integration/SMA Trigger

When in External Integrate/SMA mode, a TTL rising edge on the **TRIGGER IN** (or SYNC) signal triggers the camera to acquire one frame of data. Integration begins within 112 ns after the rising edge (132 ns in binning mode) and stops within 112 ns after the falling edge (132 ns in binning mode). After that single frame acquisition, the camera outputs the just acquired frame and “re-arms”, thus waiting for a new External Trigger signal to trigger a new frame acquisition. The camera is “armed” when the read out of the acquired frame is completed. *No additional rising edges, or triggers, should be allowed during the image acquisition or frame read out.* This means in this mode TRIGGER IN necessarily controls both integration and frame rate.

When the camera is in External Integration Mode, the MODE LED will be illuminated on the camera back to indicate the camera is expecting a signal on the SMA connector.

3.11 Controlling Frame Rate

The 4M4 allows you to control frame rate in two ways:

- **External Trigger/Internal Integration:** The camera frame rate will be controlled by the TTL pulse on the TRIGGER IN SMA connector. The camera will integrate for the programmed integration time. See section 3.10 Controlling Integration (Shutter Time).
- **External Integration:** The camera frame rate will be controlled by the TTL pulse on the TRIGGER IN SMA connector. The camera will integrate for as long as the pulse is held high. In this mode, TRIGGER IN also controls integration. See section 3.10 Controlling Integration (Shutter Time).

External Trigger/Programmed Integration

This is the same as External Integrate/SMA Trigger Mode. See section 3.10 Controlling Integration (Shutter Time).

Example: Set the Frame Rate to 2.5 fps

1. Refer to section 3.9 Triggering, Integration, and Frame Rate Overview to ensure the desired frame rate can be supported for the selected binning and integration modes.
2. Using the command 81h, set bit [0] of the data byte to 0 (Integration Mode = Internal) and bit [3] of the data byte to 1 (Trigger Mode = External).

NOTE: All bits within the register are written at one time. Ensure the correct value for all bits are used when changing camera modes.

3. Set the desired integration time according to section 3.10 Controlling Integration (Shutter Time).
4. Each TTL rising edge on the SMA connector will initiate a new frame of data, using the programmed integration time. To achieve 2.5 fps, a TTL pulse must be sent to the camera every 400 ms ($1/2.5$).

External Integration

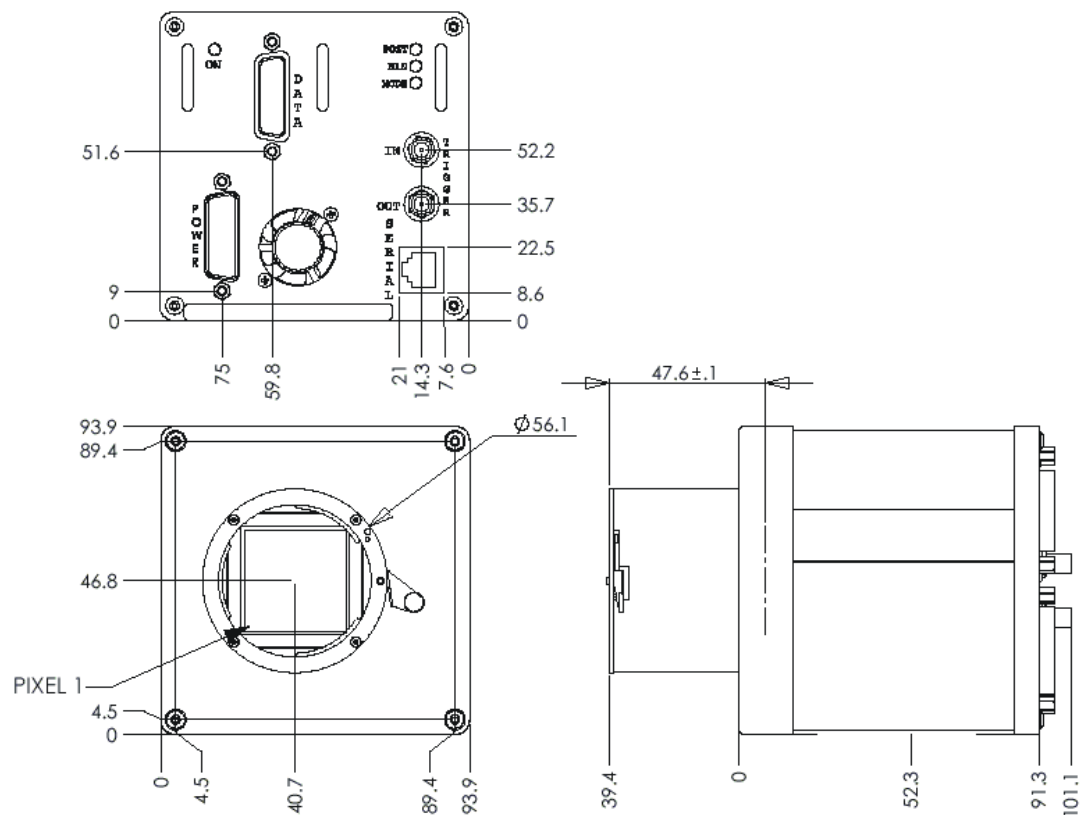
This is the same as External Integrate Mode. Refer to section 3.10 Controlling Integration (Shutter Time).

4

Optical and Mechanical Considerations

4.1 Mechanical Interface

Figure 10: Camera Dimensions



4.2 Mechanical Tolerances

Table 17: Mechanical Tolerances

Additional Dimensions	
Center of sensor with respect to lens mount	<.020"
Planarity of lens flange to sensor	<.010"
Rotation of sensor	<.3°

4.3 Mounting the Camera

The 4M4 can be mounted via the 3/8" deep, 1/4"-20 threaded tripod mount located on the bottom of the camera.

5

Cleaning and Maintenance

5.1 Cleaning

Electrostatic Discharge and the CCD Sensor

Charge-coupled device (CCD) image sensors are metal oxide semiconductor (MOS) devices and are susceptible to damage from electrostatic discharge (ESD). Although many sensor pins have ESD protection circuitry, the ESD protection circuitry in CCDs is typically not as effective as those found in standard CMOS circuits.

Electrostatic charge introduced to the sensor window surface can induce charge buildup on the underside of the window that cannot be readily dissipated by the dry nitrogen gas in the sensor package cavity. When charge buildup occurs, surface gated photodiodes (SGPDs) may exhibit higher image lag. Some SGPD sensors may also exhibit a highly non-uniform response when affected by charge build-up, with some pixels displaying a much higher response when the sensor is exposed to uniform illumination. The charge normally dissipates within 24 hours and the sensor returns to normal operation.

Preventing ESD Damage

To prevent ESD damage, DALSA advises you to take the following handling precautions:

1. Ground yourself prior to handling CCDs.
2. Ensure that your ground and your workbench are also properly grounded. Install conductive mats if your ground or workbench is non-conductive.
3. Use bare hands or non-chargeable cotton gloves to handle CCDs. **NOTE:** Rubber fingercoats can introduce electrostatic charge if the rubber comes in contact with the sensor window.
4. Handle the CCD from the edge of the ceramic package and avoid touching the sensor pins.
5. Do not touch the window, especially in the region over the imaging area.

6. Ground all tools and mechanical components that come in contact with the CCD.
7. DALSA recommends that CCDs be handled under ionized air to prevent static charge buildup.
8. Always store the devices in conductive foam. Alternatively, clamps can be used to short all the CCD pins together before storing.

The above ESD precautions need to be followed at all times, even when there is no evidence of CCD damage. The rate which electrostatic charge dissipates depends on numerous environmental conditions and an improper handling procedure that does not appear to be damaging the CCDs immediately may cause damage with a change in environmental conditions.

Protecting Against Dust, Oil, and Scratches

The CCD window is part of the optical path, and should be handled like other optical components— with extreme care.

Dust can obscure pixels, producing dark patches on the sensor response. Dust is most visible when the illumination is collimated. The dark patches shift position as the angle of illumination changes. Dust is normally not visible when the sensor is positioned at the exit port of an integrating sphere, where the illumination is diffuse.

Dust can normally be removed by blowing the window surface using clean, dry, compressed air, unless the dust particles are being held by an electrostatic charge, in which case either an ionized blower or wet cleaning is necessary.

Oil is usually introduced during handling. Touching the surface of the window barehanded will leave oily residues. Using rubber fingercoats and rubber gloves can prevent contamination. However, the friction between rubber and the window may produce electrostatic charge that may damage the sensor. To avoid ESD damage and to avoid introducing oily residues, only hold the sensor from the edges of the ceramic package and avoid touching the sensor pins and the window.

Scratches can be caused by improper handling, cleaning or storage of the sensor. Vacuum picking tools should not come in contact with the window surface. CCDs should not be stored in containers where they are not properly secured and can slide against the container.

Scratches diffract incident illumination. When exposed to uniform illumination, a sensor with a scratched window will normally have brighter pixels adjacent to darker pixels. The location of these pixels will change with the angle of illumination.

Cleaning the Sensor Window

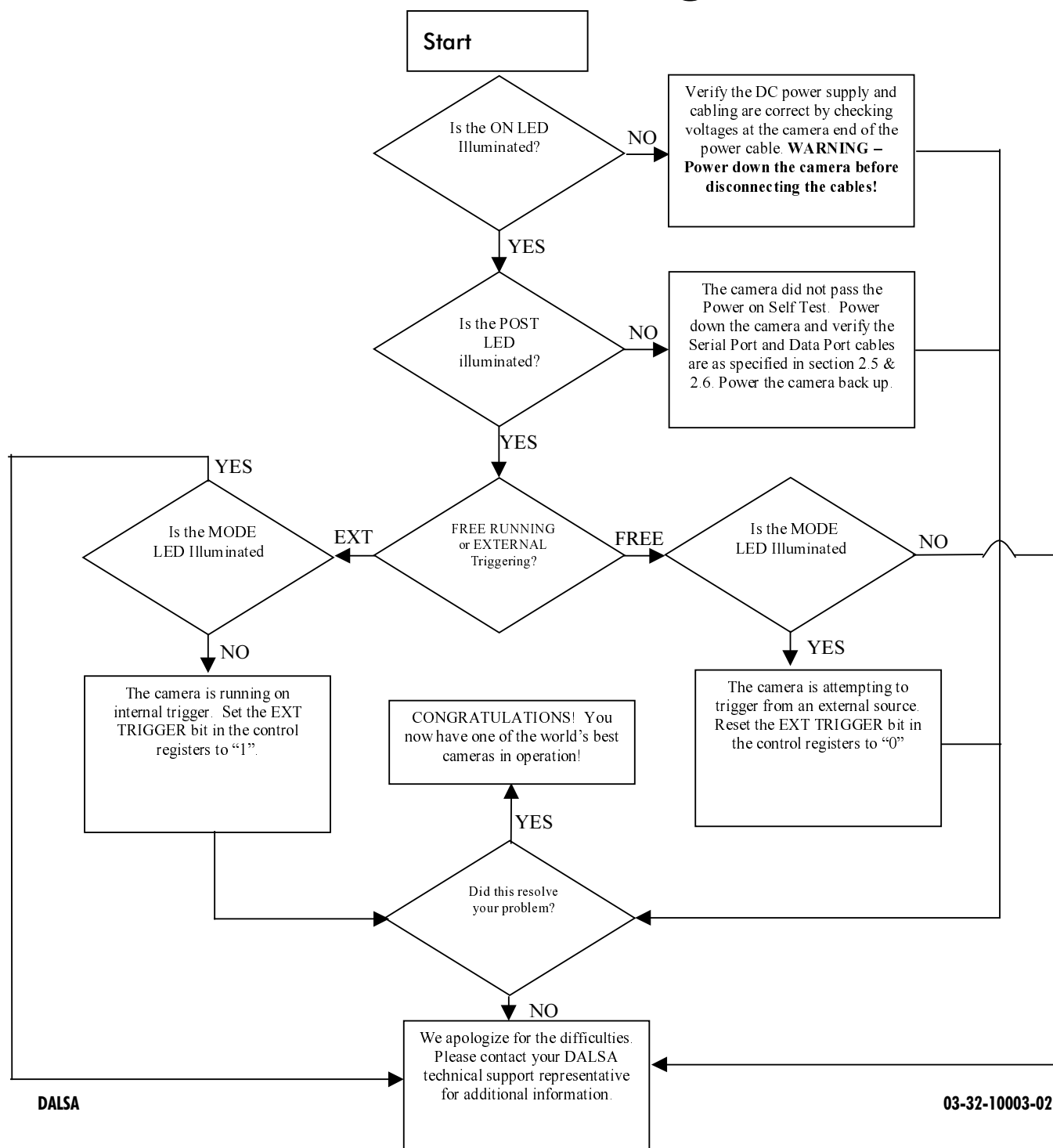
1. Use clean, dry, compressed air to blow off loose particles. This step alone is usually sufficient to clean the sensor window.
2. If further cleaning is required, use a lens wiper moistened with alcohol.
3. We recommend using lint free, ESD safe cloth wipers that do not contain particles that can scratch the window.
4. Wipe the window carefully and slowly.

Maintenance

There are no user serviceable parts on this camera. Please contact DALSA service.

6

Troubleshooting



7

Warranty

7.1 Limited One-Year Warranty

What We Do

This product is warranted by DALSA for one year from date of original purchase. Please refer to your Purchase Order Confirmation for details.

What is Not Covered

This warranty does not apply if the product has been damaged by accident or misuse, or as a result of service or modification by other than DALSA, or by hardware, software, interfacing or peripherals not provided by DALSA. DALSA shall have no obligation to modify or update products once manufactured. This warranty does not apply to DALSA Software Products.

Note: If the camera has a non-standard cover glass (e.g. taped) the warranty is void on the CCD.

How to Obtain Service for Your Equipment

If you want to return your product for repair, contact DALSA Customer Service in order to obtain a Return Goods Authorization form. Repair cannot begin until the form is issued, completed, and returned to DALSA

DALSA Technical Support

Phone: 519 886-6000

Fax: 519 886 8023

email: support@DALSA.com

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